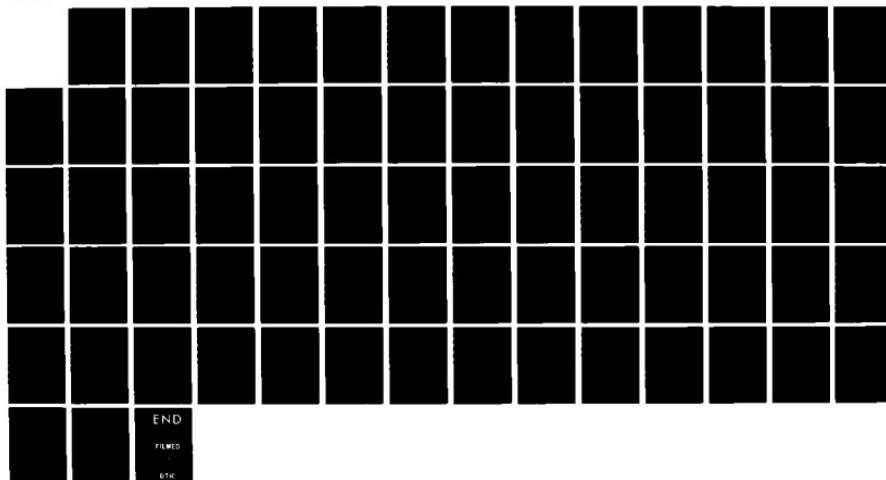


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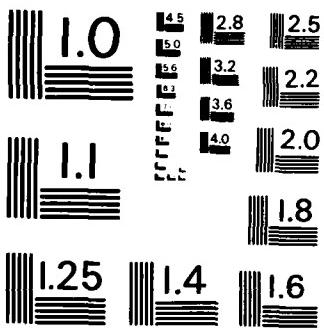
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AN ANALYSIS OF COGNITIVE STYLE FOR
USAF CIVIL ENGINEERING OFFICERS
THESIS

Alan R. Andrysiak
Captain, USAF

AFIT/GEM/LSB/35S-2

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AN ANALYSIS OF COGNITIVE STYLE FOR USAF
CIVIL ENGINEERING OFFICERS

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Engineering Management

Alan R. Andrysiak

Captain, USAF

September 1985

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Preface

I wish to thank Dennis E. (Soup) Campbell and Virgil R. Rehg for their help and assistance. Were it not for their conscientious effort and patience, this research effort could not have been accomplished. Special thanks to Heidi, Babe, and Pockets, my loyal and loving companions through all the good times and the bad.

Alan R. Andrysiak

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Abstract

This thesis used the Myers-Briggs Type Indicator (MBTI) and a demographic survey to examine the cognitive styles of Air Force civil engineering officers. The survey population was comprised of continuing education students attending the Air Force Institute of Technology, School Of Civil Engineering. The MBTI evaluates cognitive preferences using four separate scales to determine an individual's cognitive style. MBTI results were used to obtain a composite profile of cognitive style for Air Force civil engineering officers. The demographic data was used to analyze factors influencing cognitive style among civil engineering officers.

AN ANALYSIS OF COGNITIVE STYLE FOR
USAF CIVIL ENGINEERING OFFICERS

I. INTRODUCTION

As the Declaration of Independence states, all men are created equal. For this research, this famous statement of our forefathers' beliefs should be modified to read "all people are created equal but each person is unique". People are products of their genetic make-up and the environment in which they grew up(10:1). Because every person is unique, each perceives the world differently and reacts differently to those perceptions. Each person develops tendencies, sets patterns and preferred methods of relating to his/her environment. Taken together, these tendencies form an individual's cognitive style. Cognitive style is the way people prefer to use their minds to perceive and judge the world around them(10:1).

Background

This thesis will rely heavily on the typology of cognitive style, first expoused by Carl Jung in 1923. Jung

theorized that differences in personality traits and their observable actions are not a random occurrence, but one that can be explained by examining basic differences in the mental processes of individuals. These mental processes are: (1) the way that people perceive the world around them and (2) the way that they make judgments based on what they have perceived. Jung believed that an individual was born with a preference toward a particular cognitive style, but allowed that this preference can change somewhat as a person goes through life. Jung's theory has been operationalized through the Myers-Briggs Type Indicator (MBTI) developed by Katherine Briggs and Isabel Myers(1:74). The MBTI measures four variables of psychological type derived from Jung's theory. Chapter 2 reviews Jung's theory as well as the extensions of his theory by Myers, and examines related work in the research field.

Problem Statement

Managers differ in the way they manage. These differences determine the way managers identify problems confronting them in their job and the manner in which they will approach and eventually solve them. Each manager develops a decision style that he/she prefers to use. An individual's decision style is in large part governed by the way they perceive and judge information. Thus, measuring cognitive style gives an indication of different styles of managerial decision making.

Most of the Air Force officers in the Civil Engineering career field have highly technical educational backgrounds. Their education tends to emphasize analytical approaches to problem solving at the expense of neglecting the affective (or feeling) approaches (9:168) (7:478). The field of management science has steadily moved to develop analytic problem solving methods since Frederick Taylor wrote his theory on scientific management (9:188) (7:478). One would anticipate, that the combination of an analytically based education and scientific management principles, would predicate a predominance of analytic approaches in the cognitive styles of civil engineering officers.

Career progression in civil engineering moves managers out of technically oriented engineering design jobs requiring direct and frequent employment of engineering techniques into management positions with much broader responsibilities. These management positions encompass more varied decisions than those found in engineering design. Many, if not most, of the position responsibilities are similar to position responsibilities in non-engineering organizations. Analytically based cognitive styles may not be as suited for these positions. If the cognitive style profile of Air Force Civil Engineering officers is unique, the same cognitive style profile should not be reflected by the larger group of managers (engineering/non-engineering) holding similar positions in other Air Force organizations.

As an Air Force civil engineering officer progresses, varied decision styles will be required to solve the full range of problems associated with different positions. Officers will best be able to do this by developing all of their cognitive functions to support their decision style. Preferred functions are naturally developed because they are used more often (6:14). Less preferred (therefore less developed) functions may be required to effectively manage certain situations. Use of all functions is important, even if they only serve as a counter-balancing factor for the preferred function (10:13).

To accomplish this development, many officers seek additional education to improve their managerial skills. Civil engineering officers attend continuing education courses at the Air Force Institute of Technology, School of Civil Engineering. Many of these courses focus on management techniques. Masters degrees in engineering management are offered at the Air Force Institute of Technology, School of Systems and Logistics and at civilian institutions. The effect of these educational efforts is to broaden the managerial base of the civil engineering manager to make him/her more effective.

Research Objectives

The purpose of this research is to examine the cognitive styles of Air Force civil engineering officers. Collected data will be used to approximate the unique profile of

cognitive styles for the entire civil engineering population. Demographic data will be used to categorize responses into a wide range of sub-groups. Then data will be analyzed to detect any trends or differences in cognitive style among the different sub-groups. Finally, significant trends will be examined in the context of current research efforts to make recommendations for officers and educators in Air Force civil engineering.

Research Approach

To meet the objectives of this research, the first task will be to review current literature and research in the area of cognitive style. The second task will be to review the methodology used in the Myers-Briggs Type Indicator for measuring an individual's cognitive style and the basis for its selection in this research.

Collecting data on the cognitive styles employed by civil engineering officers will follow. This data will be collected from continuing education students attending the Air Force Institute of Technology School of Civil Engineering. Data will be collected using the Myers-Briggs Type Indicator (MBTI) with an accompanying demographic survey (Appendix A). Once collected, the data will be statistically analyzed to answer the following research questions.

1. What is the existing profile of cognitive styles used by Air Force civil engineering officers? Is it unique?

2. Do cognitive styles of senior and mid-level civil engineering officers differ from styles of junior officers.

3. Do the cognitive styles associated with the officers holding management positions in civil engineering differ from officers in non-management civil engineering positions?

4. Do Air Force civil engineering officers differ in their cognitive style based on their undergraduate engineering discipline?

Research Hypotheses

Research objectives will be achieved by testing the following research hypotheses. The null (H_0) and alternative (H_a) hypotheses for each research question are as follows:

Research Hypothesis 1

H_0 : The observed frequency profile of the cognitive styles of Air Force civil engineering officers is the same as that of the general population.

H_a : The observed frequency profile of the cognitive styles is distinctly different from that of the general population.

Research Hypothesis 2

H_0 : The cognitive style frequency profile for senior and mid-level officers is the same as that for junior officers.

H_a : The cognitive style frequency profile of junior officers is different than that of mid-level and senior officers.

Research Hypothesis 3

H_0 : The observed cognitive style frequency profile for Air Force civil engineering officers is the same for those holding managerial positions as those holding non-managerial positions.

H_a : The observed cognitive style frequency profile for Air Force civil engineering officers is different for managerial positions and non-managerial positions.

Research Hypothesis 4

H_0 : The observed cognitive style frequency profile for civil engineering officers is the same for all undergraduate backgrounds.

H_a : At least one of the observed cognitive style frequency profiles of Air Force civil engineering officers with dissimilar backgrounds is different.

Assumptions and Limitations

The following assumptions will be used in this thesis effort. Surveys will be correctly completed to honestly reflect the responses of the individual. Hand-scoring of the results and entry into the data base will be correct.

Limitations arise through two areas. Because the study of cognitive style is not an exact science, individual responses are inconsistent and change, resulting in an accompanying lack of precision in measurement. Style preferences are variable in strength. This is not reflected in the simple assignment of letter values to the MBTI results. Reliability and validity of the MBTI is high, but there is some respondent error in any self-administered measuring instrument. With these assumptions and limitations noted, data collection and analysis will proceed.

II. LITERATURE REVIEW OF COGNITIVE STYLE AND ASSOCIATED MEASUREMENT TECHNIQUES

Introduction

cognition "The process of knowing in the broadest sense, including perception, memory, judgment, etc." (17:276).

Cognitive style is one of many concepts used to describe human information processing. Human information processing refers to how people gather and use information in making decisions (9:187). In any analysis of decision making it is important to remember that "there is clearly a distinction between what an individual thinks (personality), and the way an individual thinks (cognitive style)" (13:502).

Personality consists of attitudes and beliefs, while cognitive style is the way individuals receive, process and transmit information. In addition to Jung's typology of psychological type, other theories defining cognitive style have been developed. Three are briefly defined below:

heuristic approach ... "designates a method of education in which the pupil proceeds along empirical lines using "rules of thumb" to find solutions or answers" (11:659).

cognitive style "The characteristic self-consistent mode of functioning which individuals show in their perception and intellectual activities" - H. Simon in The New Science of Management (1:75).

cognitive complexity Cognitive complexity is the relative complexity within an individual's conceptual system. It describes the magnitude of information an individual likes to work with.

Cognitive complexity is positively correlated with a tolerance for ambiguity and negatively correlated with authority and dogmatism. An optimal level of complexity exists; above this level leads to a reduction in individual ability to process information (9:188).

Jungian Typology

Gifts Differing (10) by Isabel Briggs Myers (with Peter B. Myers) deals with the typology of Carl Jung and the development of those ideas by Myers. The typology of managerial styles was first expoused by Carl Jung. (Jung published his theory in 1921 but the first English translation was not available until 1923). Jung theorized that differences in personality traits could be explained by examining basic differences in the mental processes of individuals. Two of these are mental processes of the way that people perceive the world around them and the way that they make judgments based on what they have perceived (10:1). Jung further stated that individuals differ in their orientation to the world around them. This personality trait is described as the "attitude type" of introversion or extraversion (2:178). The following is a synopsis of the major points of Jung's theory.

Extraversion-Introversion: The E-I Dimension. Jung's first differentiation of personality examines the focus of an individual to his/her inner or outer worlds. As evidenced by the terms, extraverts (E) are drawn to relationships between people and things, while *introverts* (I) tend to spend their

time in the inner world of their concepts and ideas. This personality type was termed an attitude by Jung (2:178). It is independent of the perceiving and judgment dimensions, termed functions by Jung (2:178).

Perceiving: The S-N Dimension. Two ways of perceiving the world, each distinct and opposite of the other, define this function. Either one may be employed by an individual. The first sensing (S), relies on the five senses of the body to detect what is going on in the world around us. Sensing types depend on direct observation of things around them through the use of the five senses (10:2). Conversely, intuitive types use intuition (N) in perceiving the world around them. Intuition is an indirect form of perception that uses the subconscious mind to enhance external stimuli (10:2). Intuitive types are more concerned with the possibilities that may exist in a situation, "what could be", rather than "what is". From early childhood on, individuals will exhibit a tendency toward one method of perceiving, using it more often and more effectively than its counterpart (10:3).

Judging: The T-F Dimension. Judging is examined similarly, differentiating between thinking (T) individuals and their feeling (F) counterparts. Differences between thinking and feeling preferences result in different judgments being made from the same set of facts given to each. Thinkers tend to concentrate on being consistent and logical in their

judging, while feelers rely more on whether ideas are good or bad, imposing or comforting, in making their judgments (10:3).

In both cases (perception and judgment), individuals tend to develop along different paths as their style influences their interests and the way they react to the world around them. Furthermore, these two characteristics are seen as independent of each other, resulting in four possible combinations of perception and judgment producing four types of personalities. These combinations (with appropriate abbreviations) are shown in Figure 1:

ST sensing plus thinking

SF sensing plus feeling

NF intuition plus feeling

NT intuition plus thinking

Figure 1. Jung's Core Combinations
(10:4)

Combining the core functions with the extraversion/introversion attitude further defines differences in psychological type. As an example, extraverts will tend to concentrate their perceptions and judgments on the real world around them and introverts on ideas in their minds (10:7).

Judgment-Perception Preference: The J-P Dimension. The fourth division among psychological types was developed by Briggs and Myers as a way of showing which function an individual uses more naturally. The J-P dimension is based on Jung's discussion of dominant and inferior functions. It shows the preference towards the judging (J) or perceiving (P) function when dealing with the outside world. As previously mentioned, perception can be made either through sensing or intuition, and judgment can be either thinking or feeling. Though both functions are used by all individuals, they cannot be employed simultaneously (10:8). Individuals will move back and forth from a judging mode to a perceptive one as the situation dictates. A preferred mode will emerge in each individual. This dimension is also independent of the other three dimensions. The combination of all four dimensions result in a total of sixteen different psychological types (ie. ESTJ) of human personality. The sixteen possible combinations are listed in Figure 2.

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

Figure 2. Myers-Briggs Four-Dimension Styles
(10:16)

Dominant vs. Auxiliary Function. Jung's theory implied that the J-P dimension (as measured by Myers) is independent of the other three dimensions. Actually, the J-P dimension indicates an individual's dominant function (S, N, T, or F). As previously stated, the J-P preference shows the way an individual deals with the outside world. The dominant process is most closely associated with (and used most often), in the world an individual feels most comfortable (10:13). Extraverts reserve use of the dominant function in dealing with the outside world, introverts will save it for their inner world. The auxiliary process will be used when an individual must deal in the arena he/she feels less comfortable with. As a result, determining the dominant process for introverts is done differently than for extraverts. The following examples show how the dominant process is determined.

Example 1 is an individual of an EST_ type. If this individual preferred sensing (S) information over that of making thinking ('T' judgements, the sensing process would be dominant. The judgement process would be used only in support of, never in lieu of, the sensing process. When judgement conflicts with perception, perception will govern. Since the individual is an extravert, he will show this dominant preference to the world, that is to say he will show an ESTP type on tests designed to measure cognitive style, or as a perceiver (P) on the J-P scale.

In example 2, the individual is an IST_. As in the first case, the individual prefers sensing (a perceptive function), to thinking. However, since this individual is an introvert, the dominant process is reserved for the inner world. The auxiliary process (in this case, judgment), is the one used with the outside world and the dominant process is kept hidden from view. As the J-P dimension measures how an individual deals with the outside world, this individual will type as an ISTJ, not as a perceiver on the J-P scale.

The auxiliary process serves as a balance in a persons character. It supports the dominant process to a degree relative to its development by the individual. Individuals who develop their auxiliary process will be better able to make sound decisions in their lives (10:13).

Implications of Jung's Theory. An individual's decision style does not indicate an absolute choice among the four dimensions (6:12). Individuals can be seen as falling on a continuum, some degree toward one end of a dimension rather than the other. Individuals can, and out of necessity, use all modes in their lives. Cognitive style indicates their preferred way of dealing however.

The relative degree of preference can change as a person goes through life (6:14). One preference may strengthen as a person is forced or chooses to use it more often. Whether a decision style is inborn or learned is a matter of some debate. Jung apparently believed it was inborn, although he

was never very clear in his writings on this point (6:14).

Each psychological type has its own characteristics. Research has shown that through self-selection, groups, whether they be based upon professions or some other category, have their own cognitive style profiles (10:41). The individual characteristics of the psychological types predominant among Civil Engineering officers will be discussed in Chapter IV. A review of recent research efforts relevant to the analysis of this thesis topic follows.

Discussion of Theories

The concept of cognitive style has been used and developed along different lines by many research works on the subject. Though these research efforts develop along the same thought processes as the theory of Carl Jung, subtle differences are evident in their cognitive dimensions. Similar differences exist in the application of the theories to practical situations.

Differences in the basis of their theories can best be discussed by reviewing their applied works. The research of Driver and Mock (3), McKenny and Keen (8), Mason and Mitroff (7), and Taggart and Robey (14) will be reviewed. Each work has applications to the civil engineering officer career field. Some of their findings will serve as the basis for the research conclusions found in Chapter V. The following is a summation of the main points of these four theories and their associated research.

Driver and Mock. Michael J. Driver and Theodore J. Mock used cognitive complexity notions such as information overload to describe cognitive style as a variant relating (1) the number of solutions considered (single vs. multiple focus) and (2) the amount of information used (high or low) in making decisions (11:320) (3:497) (4:372). Four distinct styles result: decisive (single focus, low usage), hierarchic (single focus, high usage), flexible (multiple focus, low usage), and integrative (multiple focus, high usage) (9:188) (3:497-98). Each style exhibits its own characteristic strengths and weaknesses depending upon its situational application (4:372). Figure 3 below shows how the two variables combine to produce the different styles.

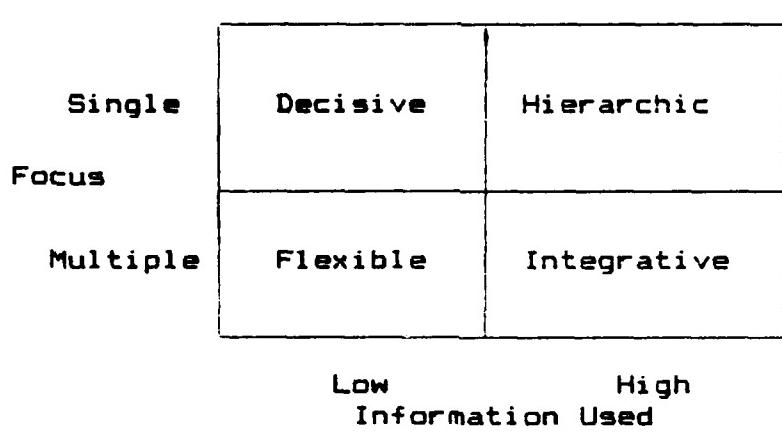


Figure 3. Cognitive Complexity Model
(15:321) (3:498)

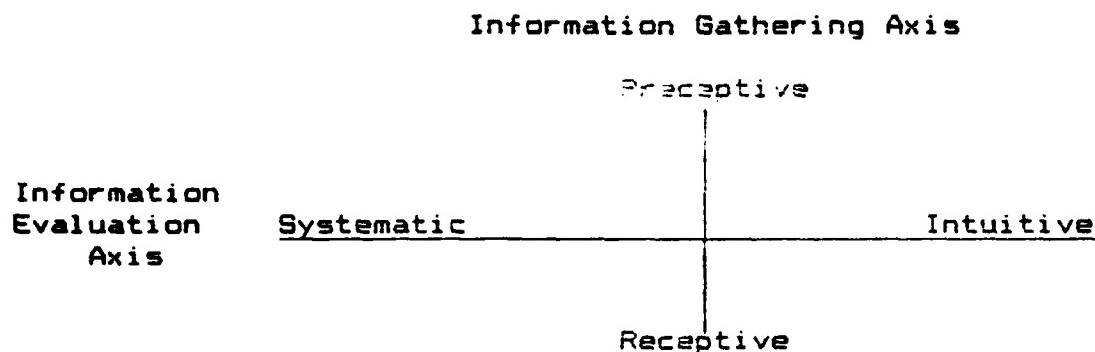
Working with Alan Rowe, Driver further researched this theory in 1979. This research culminated in the following conclusion: "the most direct application of cognitive style

is in matching managers with decision situations where their natural styles are most effective" (9:188).

McKenney and Keen. The cognitive style theory of James L. McKenney and Peter G. W. Keen emphasizes "modes" of information gathering and information evaluation (4:372) (8:80). Information gathering may be preceptive or receptive in nature. A systematic or intuitive approach may be used for evaluating information.

"Information gathering relates to the essentially perceptual processes by which the mind organizes the diffuse verbal and visual stimuli it receives" (8:80). The complex coding of the stimuli into information is different in preceptive and receptive individuals (8:80). Preceptive individuals filter data by relating it to known relationships and noting deviations from expectations (8:80). Receptive thinkers dwell more on the detail of the data itself, deriving attributes from direct examination rather than how it fits into their precepts (8:81).

Information evaluation deals with what are commonly classified as problem solving techniques (8:81). Systematic individuals tend to structure a problem so that some particular method, when followed, will lead to a solution (8:81). The strategy of intuitive thinkers is more of a trial and error process. They tend to jump from one solution to another based on intuition regarding the information (8:81). The theory relationships are summarized in Figure 4.



**Figure 4. McKenney and Keen Decision Style Model
(8:81)**

Each axis on the model has its advantages when used in particular problem solving situations. A systematic individual tends to minimize effort by using set procedures. This works well in problems involving known constraints (8:81). Intuitive thinkers do well in unstructured situations where a predetermined method for solving the problem does not exist (8:81). Similarly, preceptive style works well in planning while receptive styles are more suited to detail work such as auditing (8:81).

The likelihood that a manager will use a particular technique for problem solving is directly related to his or her cognitive style. Taking it one step further, managers analyze their environment to determine what problems exist that require their attention. Managers with different values (and different cognitive styles), will often perceive different problems (8:81). A manager will look for problems

that match his decision style because he is more comfortable dealing with them (8:83).

Mason and Mitroff. Richard O. Mason and Ian I. Mitroff employ the Jungian typology, to describe cognitive style. They theorized that individuals differ along two basic dimensions: (1) types of information acquisition, and (2) modes of data processing.

Individuals range from sensation-oriented to intuitive in the information acquisition dimension (4:373). A sensing person likes structural problems and is able to deal with routine, precise tasks. Intuitive individuals tend to ignore structure focusing on the problem as a whole, and prefer unstructured non-routine work (4:373). This dimension correlates well with McKenney and Keen's information gathering dimension.

The evaluation approach (the mode of data processing), is divided into two groups of feeling and thinking individuals (4:373)(7:477). The feeling individual considers values important and uses feelings and emotions in his evaluations. In contrast, the thinking individual is impersonal in his evaluation, and depends on logic and analysis to arrive at decisions (4:373)(7:478).

Mason and Mitroff found that the two dimensions, acquisition and evaluation, were independent, leading (as in the other models) to four pure cognitive styles. These four styles are sensation-intuition (ST), sensation-feeling (SF),

intuition-thinking (NT), and intuition-feeling (NF). Although the styles are conflicting (as opposed to cooperative), no one style is superior to or more basic than the others (4:373) (7:477).

Taggart and Robey. William Taggart and Daniel Robey introduce the concept of dual human information processing. Their work is rooted in the Jungian typology and additionally considers the philosophical explanations of man's' duality (9:187).

Human duality, the dual aspect of human personality, can be seen in art, philosophy, religion, and more recently in the behavioral and medical sciences. One perspective shows man as "logical and rational, goal directed and scientific, technical and analytical" (9:187). The other aspect highlights the "mysterious and intuitive, nonlogical and subjective, artistic and emotional" side of man (9:187).

Traditionally these characteristics were most often used to differentiate between people, but recent medical study supports the existence of both mind sets in everyone (9:187). These studies have shown that each hemisphere of the brain reacts differently to information. The left side contains the analytical and verbal processes, the right hemisphere governs spatial and intuitive thinking. The four jungian decision styles lie on a continuum that ranges from a left dominant to right dominant mode (9:173) (6:13).

Each cognitive style is complemented by strategies which

suggest alternative managerial approaches to the person and environment. Taggart and Robey see implications that a successful manager will use the full range of processing skills (9:188). "This suggests the need for flexible, situationally dependent styles and strategies for decision making" (9:188).

Summary

This chapter reviewed the typology of Carl Jung, including the typology modifications made by Isabel Myers and Katherine Briggs. Several research works were detailed to show applications of typology research.

These research efforts reinforce the theory that individuals have a characteristic cognitive style which they prefer to use. This style influences the way that they perceive information and make judgments based on that information. Differing cognitive styles seem to be suited for and attracted to different interests and occupations. This attraction is evidenced in the repeated selection of an occupation by individuals of a particular cognitive style.

Cognitive styles are not fixed and definite. An individual necessarily employs more than one style (duality) because all situations are not the same. Proper development of less preferred cognitive styles is essential for success in career and social situations.

The following chapter will review the methodology employed by the Myers-Briggs Type Indicator. Selection of a

sample population, sample technique, and the specific methodologies used in collecting and analyzing the data for this study will also be discussed.

III. Methodology

This section describes the specific methodology used in answering the research questions of Chapter I. The methodology of data collection and analysis procedures are reviewed.

Review of Research Objectives

The objective of this thesis is to analyze the cognitive style profile of USAF Civil Engineering officers. Demographic data are used in conjunction with the cognitive style data and statistical analysis to answer the research questions outlined in Chapter I.

Population and Sample

This research uses as its population, USAF officers currently assigned to the Civil Engineering career field. Continental United States (ConUS) based and overseas based personnel are included in this population. Data was collected by surveying continuing education students at the Air Force Institute Technology (AFIT) School of Civil Engineering, at Wright-Patterson Air Force Base. This method was chosen to take advantage of the large number of students that could be reached in person. This method allowed greater control in the administration of the survey instrument.

Questions and problems that arose were handled by the researcher as they arose. The proposed class schedule produced a sufficient number of subjects to facilitate this study and minimized the collection time and total cost.

Measurement Instrument

One recognized problem in collecting data on cognitive style involves the reliability and validity of the measurement instrument (14:381). A secondary concern involves the economy and convenience of the collection tool.

Cognitive style collection tools include physiological state indicators (electroencephalograms etc.), observation of behavior during designed psychological tests, and self-description inventories (14:375). Considering the time and fiscal constraints placed on this research effort, the self-description inventories were the logical choice to pursue as a measuring instrument.

Upon evaluation, the Myers-Briggs Type Indicator has been selected as the measurement instrument to be used in this research. Of the self-description inventories, the Myers-Briggs Type Indicator (MBTI), developed by Isabel Briggs-Myers and her mother Katherine Briggs has undergone extensive review process for reliability and validity (14:381). Its wide use has developed a significant research base (7) (4) for comparison.

To determine cognitive style, the MBTI uses forced-choice questions which indicate a preference of one

style dimension over its counterpart. Points are given for each preference. These points are totaled, resulting in eight scores. These eight scores are treated as four pairs, corresponding to the four dimensions of the Jungian typology. The larger score in the pair indicates a preference toward that type. For example, a score of 23 for judgement (J) and 9 for perceptive (P) indicates the person prefers the judging mode over the perceptive mode dealing with the outside world. Tie scores are assigned to the least represented preference letter of the dimension (i.e., I, N, T, and P). The scores are totaled for each dimension. The final result places a person in one of the 16 different types shown in Figure 2 in Chapter II.

Data Analysis

Data Compilation. Completed MBTI answer sheets were scored by hand. The results, along with the demographic data were entered into data files on the AFIT Harris computer for analysis by the Statistical package for the Social Sciences (SPSS). The subroutine FREQUENCIES was used to tabulate the demographic data. Tables of the demographic distribution of responses can be found in Appendix B.

Test Statistic. The primary analysis technique used in testing the research hypotheses was nonparametric chi-square analysis. Chi-square analysis tests for goodness of fit for data that falls into categories (5:222). Chi-square analysis is employed by selecting the SPSS subroutines NPAR TESTS and

CROSSTABS (5:222) (12:218). A brief review of the test statistic computed for chi-square analysis can be found in Appendix C.

To test research hypothesis 1, the subroutine NPAR TESTS was used to perform a One-Sample Chi-Square analysis. This analysis procedure is used to test whether a significant difference exists between observed data distributions and expected distributions (5:222). Expected data is directly entered into the subroutine using the statement "Expected=" (5:223). The SPSS subroutine automatically tests observed data cases against these values.

Research hypotheses 2, 3, and 4 were tested using crosstabulation. The CROSSTABS procedure computes and displays two-way to n-way crosstabulation tables for any discrete variables (12:218). Expected proportions are assumed equal based on no underlying relationships among the variables. Tests of statistical significance and measures of nominal and ordinal association are available with this sub-program (12:216).

Other Analysis Tools. In addition to chi-square analysis, the Self-Selection Ratio (SSR) will be used to analyze individual types in question 1. The SSR compares "the percentage frequency of that type in the sample divided by its percentage frequency in the base population" (10:40). The ratio of (Actual/Expected) is used to determine self-selection or avoidance in the group population for that

type.

Values greater than 1.00 indicate a proportionately greater percentage of persons of that type in the sample population than in the general population. Higher values of SSR show self-selection (attraction) to the group for that type relative to the base population. The greater the value, the stronger the attraction. Conversely, values less than one show avoidance of the group by that type with values closer to zero showing stronger avoidance (10:41).

Significance Level. A minimum significance level (α) of [0.05] was chosen to evaluate each hypothesis. This value (i.e., a 95 percent confidence interval) is generally accepted as statistically significant in social science research (12:222). Actual significance levels below this value are shown where applicable in the analysis section of Chapter IV.

IV. Results and Analysis

Introduction

This chapter presents results from the data collection, and the analysis of the hypotheses stated in chapter 1. This data was collected using a demographic survey and the Myers-Briggs Type Indicator (MBTI). The analysis was performed using selected subroutines found in Statistical Package for the Social Sciences (SPSS).

Survey Response

A total of 187 surveys were distributed to students attending Civil Engineering continuing education courses at AFIT. Of that number, 120 were completed and returned to the researcher. Four cases were eliminated because of incomplete or incorrectly completed surveys. Data for the remaining 116 cases were tabulated, and the SPSS subroutine FREQUENCIES generated tables showing the responses to each question. Respondents personal demographic data (ie., Rank, Degree), used to facilitate breaking responses into sub-groups, can be found in Appendix B.

Analysis of each of the four research questions involved testing the research hypotheses. A minimum significance level (alpha) of [.05] was used in testing each hypothesis. However, the capabilities of SPSS allow the precise significance of the statistical results (the P-value) to be

reported for each case (12:271).

Research Question 1

1. What is the existing profile of cognitive styles used by civil engineering officers? Is it unique?

H_0 : The observed frequency profile of the cognitive styles of Air Force civil engineering officers is the same as that of the general population.

H_a : The observed frequency profile of the cognitive styles is distinctly different from that of the general population.

MBTI Type Analysis. Research question one is answered by comparing the MBTI results obtained in this research with the MBTI profile for a standard base population. Table I shows expected results for administration of the MBTI to a random sample of 116 individuals selected from the general population(6:25). Percentages for each type cell were calculated by multiplying together the population percentages for each individual dimension. A sample calculation (for ISTJ) shows this procedure:

$$(I)ntraversion \times (S)ensing \times (T)hinking \times (J)udgment = cell \% \\ (.25) \quad \times \quad (.75) \quad \times \quad (.60) \quad \times \quad (.50) \quad = \quad 5.6\%$$

Multiplying the percentages obtained for each type (for the general population) by 116, produces expected numbers of responses in each category for the research sample size. Table I shows the expected total and corresponding percentage for each of the 16 MBTI types.

TABLE I

Expected MBTI Type Distribution for Males by Quantity and
Percent*
N =116

Type	<u>ISTJ</u>	<u>ISFJ</u>	<u>INFJ</u>	<u>INTJ</u>
Number	07	04	01	02
Percentage	5.6	3.8	1.3	1.9
Type	<u>ISTP</u>	<u>ISFP</u>	<u>INFP</u>	<u>INTP</u>
Number	07	04	01	02
Percentage	5.6	3.8	1.3	1.9
Type	<u>ESTP</u>	<u>ESFP</u>	<u>ENFP</u>	<u>ENTP</u>
Number	20	13	04	07
Percentage	16.9	11.3	3.8	5.6
Type	<u>ESTJ</u>	<u>ESFJ</u>	<u>ENFJ</u>	<u>ENTJ</u>
Number	20	13	04	07
Percentage	16.9	11.3	3.8	5.6

*Totals do not add to 100% due to rounding.

Table II shows actual results obtained in this research. In addition to the total number and percentage for each response, Table II includes the Self-Selection Ratio. The Self-Selection Ratio (SSR) is computed by taking the ratio of Actual/Expected values for each of the sixteen MBTI types (10:40).

TABLE II

Sample MBTI Type Distribution by Quantity and Percent with
 Self Selection Ratio (SSR)
 N =116 (males)

Type	<u>ISTJ</u>	<u>ISFJ</u>	<u>INFJ</u>	<u>INTJ</u>
Number	31	04	00	14
Percentage	26.7	3.4	0.0	12.1
SSR	4.77	0.89	0.0	6.37
Type	<u>ISTP</u>	<u>ISFP</u>	<u>INFP</u>	<u>INTP</u>
Number	06	01	05	08
Percentage	5.2	0.9	4.3	6.9
SSR	0.93	0.24	3.31	3.63
Type	<u>ESTP</u>	<u>ESFP</u>	<u>ENFP</u>	<u>ENTP</u>
Number	02	03	02	06
Percentage	1.7	2.6	1.7	5.2
SSR	0.10	0.23	0.45	0.93
Type	<u>ESTJ</u>	<u>ESFJ</u>	<u>ENFJ</u>	<u>ENTJ</u>
Number	20	01	02	11
Percentage	17.2	0.9	1.7	9.5
SSR	1.02	0.08	0.45	1.70

Values greater than one indicate a proportionally greater percentage of persons of that type in the sample population than in the general population. SSR values 1.20 or larger show significant "self-selection" of engineering by that MBTI type(10:41). Conversely values less than 0.85 show

significant avoidance of engineering by that type, with values closer to zero showing stronger avoidance (10:41).

SSR values show a high concentration (greater than 1.20) of respondents in five of the sixteen MBTI types (ISTJ, INTJ, INFP, INTP, ENTJ). They comprise 59.3% of the sample population, far greater than the expected 16.3% of the base population. Four MBTI types show slight self-selection or avoidance. These types (ISFJ, ISTP, ENTP, ESTJ) are represented equally in both the sample and base populations.

The remaining seven MBTI types (INFJ, ISFP, ESTP, ESFP, ENFP, ESFJ, ENFJ) show a strong avoidance to the civil engineering career field. These seven cells together comprise only 9.5% of the civil engineering respondents. This is less than one-fifth of the 52.2% proportion in the base population.

The actual and expected values for MBTI type were compared using the nonparametric One Sample Chi-Square analysis technique on SPSS. The resulting probability that the two distributions could be from the same population was shown to be less than 0.001. From this result, the null hypothesis that the cognitive style profile of Air Force civil engineering officers is the same as the base population, is rejected and the distribution is found to be significantly different from the base population.

Single Dimension Analysis. As a means of further determining the group distinctness of the MBTI types of USAF

TABLE III
Individual MBTI Dimension Distributions for Sample

N =116 (males)

Dimension	Preference	Number	Percent
E-I	Extraversion	47	40.5
	Introversion	69	59.5
S-N	Sensing	68	58.6
	Intuition	48	41.4
T-F	Thinking	98	84.5
	Feeling	18	15.5
J-P	Judging	83	71.6
	Perception	33	28.4

civil engineering officers, responses for each of the four dimensions were analyzed. Table III displays the research responses obtained in each of the four separate MBTI dimensions (E-I, S-N, T-F, J-P).

Expected percentages for each of the four dimensions, established for the general population will be used as a means of verifying the results. The ratio of Extraverts to Introverts in the general population is 75%(E) to 25%(I) (6:25). The expected proportion for Sensing vs Intuition is also 75%(S) to 25%(N) (6:25). The Thinking - Feeling preference is gender dependent (6:20). For males (the

research sample was 100% male), the expected ratio is 60%(T) to 40%(F). Equal proportions, 50%(J) to 50%(P) are expected for the Judgment vs Perception distribution (6:25).

Nonparametric chi-square analysis of each dimension shows USAF Civil Engineering officers differ significantly from the expected distributions ($p < .001$ in all cases) for all four dimensions. These results correspond with those found for the full MBTI type analysis. Additionally, single dimension analysis shows that the significance attained in the full MBTI type analysis is not due to just one or two of the dimensions, but is shown in all four.

Research Question 2

Do cognitive styles of senior and mid-level civil engineering officers differ from styles of junior officers?

H_0 : The cognitive style frequency profile for senior and mid-level civil engineering officers is the same as that for junior officers.

H_a : The cognitive style frequency profile of junior civil engineering officers is different than that of mid-level and senior officers.

The research hypothesis was designed to examine the effects of increasing military rank on the cognitive styles of civil engineering officers. Higher ranking civil engineering officers generally hold different positions than their more junior counterparts. Individual self-selection (to stay in civil engineering/stay in the Air Force) was expected to result in a different profile of cognitive styles for senior and mid-level officers.

TABLE IV
Individual Preference Distributions for Sample
By Rank

Preference	N =116 (males)		Chi-square Test Results
	Junior Officers	Senior Officers	
Extraversion	30	16	$\chi^2 = 1.30$
Introversion	41	28	$p = 0.25$
Sensing	42	25	$\chi^2 = 0.81$
Intuition	29	19	$p = 0.37$
Thinking	57	14	$\chi^2 = 0.01$
Feeling	40	04	$p = 0.96$
Judging	47	35	$\chi^2 = 0.03$
Perception	24	09	$p = 0.85$

To answer this research question, responses were divided into two groups. The first group included all Lieutenants responding to the survey. The second group contained the remainder of the sample responses from Captain thru Colonel.

Table IV, a crosstabulation of single dimension distributions (E-I, S-N, T-F, J-P) was obtained and analyzed using the CROSSTABS procedure on SPSS (12:231). An analysis of the 16 MBTI types was not feasible because 77% of the expected cell frequencies fell below five (see Appendix C). As shown in Table IV, no statistically significant differences ($p < .05$) were measured between the two groups.

This resulted in failure to reject the null hypothesis for research question 2.

The selection of groups in this analysis procedure was not arbitrary. Inclusion of captains in the mid-level/senior group generated a balanced distribution of responses with a sufficient number of responses in each group. A chi-square analysis was also preformed with captains as part of the junior officer group. Again, no statistically significant differences were found.

The analysis resulted in chi-square probabilities above 0.25 for each dimension. These values do not represent even marginally significant differences between the groups. Thus this research indicates that the as measured by rank, cognitive styles of the senior and mid-level civil engineering officers (as reported by the MBTI) are of substantially the same distribution as their junior level counterparts

Research Question 3

What are the cognitive styles associated with civil engineering officers assigned to management and non-management positions?

H_0 : The observed cognitive style frequency profile for Air Force civil engineering officers is the same for those holding managerial positions as those holding non-managerial positions.

H_a : The observed cognitive style frequency profile for Air Force civil engineering officers is different for managerial positions and non-managerial positions.

This third research question is asked to determine if the MBTI dimensions differ among individuals, depending on whether or not they are currently in management positions. In light of the negative results for the second research question, and the similarity of the grouping variables, positive results in this area would indicate a measure of job influence on the dimensions.

Group 1 consisted of respondents who indicated that they were assigned to the engineering design section. The primary responsibilities of members of engineering design revolve around the preparation of specifications and technical drawings for Air Force construction and maintenance projects. This group is defined as the non-management positions. Group 2 consisted of the remainder of the sample, those holding positions that involve more management functions (i.e., Base Civil Engineer, Chief of Readiness, Chief of Operations). These positions are less involved with the technical aspects of engineering and more involved with management of people and resources.

Crosstabulation was again used as the analysis procedure. Results of this analysis are found in Table V. As before, analysis of each of the 16 types was not feasible due to a high percentage of cells with expected frequencies below 5. No significant results were found for any of the dimensions. Chi-square probability ranged from 0.31 to 0.87, indicating no values even marginally significant.

TABLE V
Individual Preference Distributions for Sample
By Position Category

Preference	N =116 (males)		Chi-square Test Results
	Non- Management	Management	
Extraversion	26	20	$\chi^2 =0.30$
Introversion	36	30	$p =0.58$
Sensing	40	24	$\chi^2 =1.03$
Intuition	22	26	$p =0.31$
Thinking	52	43	$\chi^2 =0.03$
Feeling	10	07	$p =0.87$
Judging	43	36	$\chi^2 =0.08$
Perception	19	14	$p =0.77$

The results of research question three support the results obtained for question 2. This is not surprising given that the group populations are similar. The null hypothesis is not rejected. The research cannot show a difference in the distributions for those in management and non-management positions.

Research Question 4

Do Air Force civil engineering officers differ in their cognitive style based on their engineering discipline?

H_0 : The observed cognitive style frequency profile for civil engineering officers is the same for all undergraduate backgrounds.

H_a : At least one of the observed cognitive style frequency profiles of officers with different backgrounds is different.

Research question 4 sought to determine if the undergraduate major chosen by an individual is influenced by cognitive style. The choice of an engineering discipline is a major decision in an individual's life. It shapes and determines the direction a person will take in life. Given the significance found in MBTI profiles among different groups, selection of a discipline was hypothesised to show similar results.

For the analysis of this question, the responses were split into three groups. Group 1 included all respondents with civil engineering degrees. Group 2 contained a combination of mechanical engineers and electrical engineers. The third group was comprised of architects.

Crosstabulation and chi-square analysis was again used as the testing procedure. Results from this analysis are found in Table VI. Significant differences were found in the E-I dimension and the S-N dimension. No significant differences were found in the T-F and J-P dimensions.

In the E-I dimension, architects were found to be significantly more extraverted (64.3%) than either the civil engineers (36.4%) or the mechanical/electrical engineers (30.4%). The majority of the two engineer groups (65.2%)

TABLE VI
Individual Preference Distributions for Sample
By Engineering Discipline

Preference	N =116 (males)			Chi-square Test Results
	Civil	Electrical Mechanical	Architect	
Extraversion	24	07	09	$\chi^2 = 4.67$
Introversion	42	16	05	$p = 0.05$
Sensing	47	10	05	$\chi^2 = 9.53$
Intuition	19	13	09	$p = 0.009$
Thinking	54	20	12	$\chi^2 = 0.38$
Feeling	12	03	02	$p = 0.83$
Judging	48	14	12	$\chi^2 = 2.73$
Perception	18	09	02	$p = 0.26$

were introverts. The chi-square probability of random chance causing this difference is .045.

This result may be due to an increased focus on people and things by architects. Architects must be able to effectively communicate their ideas and interact with others in their design process. The engineer groups do not have as great a requirement in this area. They deal more with mathematical relationships and abstract ideas.

The second significant result obtained in this analysis was in the perception function. Civil engineers had a much

higher sensing preference in the perception function (75.8%). Architects (35.7%) and mechanical/electrical engineers (43.5%) showed preference for intuition. The corresponding chi-square probability (.009), shows less than one chance in one-hundred of random chance causing such a large difference.

This result is explainable if one considers differences in cognitive structures between the groups. Civil engineers deal with factual data gained from past experience and applied to current situations. Working with pavements, soil, concrete, and structures, variations in actual conditions are fit to existing formulas based on past success. Conversely, architects rely on more than established data and formulas in their work. Concepts integral to architecture, such as form and function use past experience of success, but are more intuitively oriented. Architects use intuition, in the form of speculation, hunches and possibilities, to develop "formulas" that will fit the present situation. Mechanical and electrical engineers also work to fit formulas to existing situations. Air-flow, current load, and resistance are not standardized from case to case as many of the civil engineering concerns. Ingenuity is often required in each new occurrence to arrive at the best solution.

The significant differences observed in two of the four MBTI dimensions lead to the rejection of the null hypothesis for research question 4. The alternative hypothesis that at least one of the frequency profiles is different can be shown through the analysis procedure.

V. Conclusions and Recommendations

Introduction

This chapter discusses the conclusions drawn from the analysis of the previous chapter. Limitations of the results analysis are examined with the benefit of hindsight. Finally this chapter gives recommendations for further research on this topic.

Limitations

The conclusions discussed in this chapter are based on some limiting assumptions concerning the data collection of this research. The first limiting assumption is that the sample population is representative of the entire population of Air Force civil engineering officers. This is a rather strong assumption. The continuing education students surveyed at the AFIT School of Civil Engineering are not a random sample of all civil engineering officers. The courses offered during the data collection period were not totally representative of all civil engineering disciplines. Additionally, the fact that the students were attending continuing education courses biases the sample. The biased sample may have skewed results in a particular dimension of Jung's typology, but any skewness was not readily apparent. The second limiting assumption deals with the group designations used in the analysis of research questions 2-4.

Because of small survey response in general, and in particular some of the undergraduate engineering disciplines, groups were combined to facilitate statistical analysis. These groups were not combined arbitrarily, but instead were matched in combinations that had logical similarities.

Given these limitations, this research has value as a first study of cognitive style in the civil engineering career field. It can serve as a starting point for future research efforts in the area.

Conclusions

Considering the limitations of the study, the conclusions presented in this section are of a general nature such that they retain their research value. No marginally significant results were used in the development of these conclusions.

1. Air Force civil engineering officers have a unique characteristic profile of cognitive styles. The significance level ($p < .001$) of the analysis results is not unexpected, in light of the prior research on cognitive style relative to career choices. A negative result, indicating a profile very similar to the general population, would have been much more surprising.

Had a profile similar to that of the general population been observed, it would have indicated that the Air Force civil engineering career field has no characteristics that separate its member officers from other professions.

Similarly, it would have meant the job tasks and responsibilities of a civil engineering officer would not have attracted any particular type of individual. The particular talents and interests common to Air Force civil engineering officers unmistakeably show us otherwise.

As measured by the MBTI, the type profile is heavily distributed towards types showing a thinking (T) preference. Substantially more introverts (I) were found in the sample respondents than expected in the general population. An equally strong response was observed for the Judging preference (J) in dealing with the outside world. The overall type characterization of the Air Force civil engineering officers would be as follows:

One dimension : (T) -84.5%
Two dimension : (ST) -50.8%
Three dimension: (STJ) -43.9%
Four dimension : (ISTJ) -26.7%

The dominant pairing of responses in the survey was (TJ). This one combination was present in almost two-thirds of the MBTI types.

2. The cognitive style profile of Air Force civil engineering officers does not change with career progression. This similarity occurs despite the fact that job responsibilities change as a civil engineer progresses. The conclusion, as a direct consequence of the negative results obtained for the second and third research questions, indicates that cognitive style is not altered radically due to increased management responsibilities, individual

maturity, and education level.

The self-selection process of continuing in the career field is likely similar to that which caused individuals to become civil engineering officers in the first place. Not considered in the research, but extremely important, is the fact that selection of the Air Force as a career constitutes a self-selection almost equal to that of becoming an engineer. It may be that it is this career choice that more greatly determines the cognitive style profiles of Air Force civil engineering officers.

3. Engineering undergraduate disciplines do reflect differences in cognitive style profiles among Air Force civil engineers. Realization of the differences among disciplines has practical applications in the work environment. Recognition of the cognitive style of fellow officers can lead to a greater understanding of the way that they think.

People of differing types see problems and develop solutions differently. Thus, a situation that frustrates an individual or group of a particular type, can receive fresh insight from an individual of opposing type.

Knowing one's own type can help us to better make ourselves understood to coworkers. If one understands that one is functioning at a different level because of cognitive differences, one can take the time to clearly explain one's mental processes to others. Different cognitive types may

not agree with how each other thinks, but they are likely to come to an understanding of why individual responses are different. This understanding, in turn, can lead to better working relationships being fostered.

Recommendations

The use of the Myers-Briggs Type Indicator opens a wide vista of possibilities for research in civil engineering. The use of demographic data and statistical procedures such as crosstabulation, makes comparisons flexible to examine many sub-groups. The MBTI is growing as a research and management tool (6). There are many research works available for use as models for new studies and as comparison databases.

Recommendations for further research include:

1. A longitudinal study to examine the effects of the Graduate Engineering Management (GEM) program (and possibly other educational programs) on the cognitive styles of Air Force Civil Engineering officers.
2. A study of the effects on job satisfaction and performance of knowing one's own cognitive style. This would require combination use of a survey instrument and individual conferences with participants. A follow-on survey would be required for long-term effects and feedback.
3. A study of the cognitive styles of successful senior (colonel and above) Air Force civil engineering officers. This research could look for particular preferences that correspond with reaching the top of the

profession.

4. A comparison study of cognitive style of Air Force civil engineering officers with other Air Force officers to determine the effect of cognitive style on the choice of the Air Force as a career relative to the self-selection of a particular career field.

These recommendations are just a few of the many interesting possibilities for future research in this area. The background of the Jungian theory and the Myers-Briggs Type Indicator, provide a solid basis to for practical application on a personal and organizational level.

Appendix A: Demographic Survey

The following demographic data will be combined with the Myers-Briggs Type Indicator in a Masters thesis in the AFIT School of Systems and Logistics. Please take your time to carefully read and answer the following questions and the attached MBTI survey. Your time and effort is appreciated. (These surveys are controlled items due to their cost and the difficulty in obtaining them. Be sure to return all materials upon completion.)

1. What is your current rank?

- a. O-1
- b. O-2
- c. O-3
- d. O-4
- e. O-5
- f. O-6

2. How many years of active duty service do you have?

3. How many years of Civil Engineering squadron experience do you have?

4. Do you have prior enlisted service?

- a. no
- b. yes _____ years

5. What is your current job title?

6. How many months experience do you have at your current job?

months

7. What major Air Force command are you currently assigned to?

(over)

8. What best describes your Engineering background.

- a. Civil Engineer
- b. Mechanical Engineer
- c. Electrical Engineer
- d. Industrial Engineer
- e. Other (please list) _____

9. What is your advanced degree status? (choose all that apply.)

- a. Engineering masters degree.
- b. Management masters degree.
- c. Business Masters degree
- d. Other (please list) _____
- e. Working towards degree.
- f. No advanced degree

10. Are you a graduate of the AFIT Facilities Management or Engineering Management masters program?

- a. yes
- b. no

11. Are you a rated officer working in a rated supplement position?

- a. yes
- b. no

12. Have you served a tour at the major command level?

- a. yes
- b. no

13. What sex are you?

- a. male
- b. female

14. What is your marital status?

- a. never been married
- b. married
- c. divorced

Appendix B: Selected Demographic Data Distributions

The following distributions were obtained using the SPSS subroutine FREQUENCIES. Response rates are different because some questions were omitted on some responses.

Table VII
Survey Respondents by Rank

N=115		
Rank	Number	Percent
2nd Lieutenant	32	27.6
1st Lieutenant	39	33.6
Captain	21	18.1
Major	11	9.5
Lieutenant Colonel	11	9.5
Colonel	1	0.9

TABLE VIII
Survey Respondents by Marital Status

N=111		
Status	Number	Percent
Single	38	34.2
Married	69	62.2
Divorced	4	3.6

Table IX
Survey Respondents by Active Duty Service Time

N=114

Years	Number	Percent
0 to 2.5	28	24.6
2.5 to 4.5	32	28.0
4.5 to 8.5	14	12.3
8.5 to 12.5	15	13.2
12.5 to 16.5	8	7.0
16.5 to 20.5	15	13.2
Over 20.5	2	1.8

TABLE X
Survey Respondents by Civil Engineering Experience

N=114

Years	Number	Percent
0 to 2.5	54	47.4
2.5 to 4.5	32	28.0
4.5 to 8.5	14	12.3
8.5 to 12.5	8	7.0
12.5 to 16.5	4	3.5
16.5 to 20	2	1.8

TABLE XI
Survey Respondents by Civil Engineering Job Title

Job Title	Number	Percent
HQ Staff Officer	12	10.5
Chief/Requirements	8	7.0
Chief/Readiness	11	9.6
Design Engineer	62	54.4
Industrial Engineer	3	2.6
Chief Operations	8	7.0
Base Civil Engineer	8	7.0
Other	2	1.8

TABLE XII
Survey Respondents by Advanced Degree Status

Status	Number	Percent
No Advanced Degree	47	42.0
Engineering Masters	11	9.8
Management Masters	23	20.5
Business Masters	5	4.5
Other Advanced Degree	2	1.8
Working Toward Degree	24	21.4

TABLE XIII
Survey Respondents by Bachelors Degree

N=114

Degree	Number	Percent
Civil Engineering	66	57.9
Mechanical Engineering	16	14.0
Electrical Engineering	7	6.1
Industrial Engineering	8	7.0
Architecture	14	12.3
Other	3	2.6

Table XIV
Survey Respondents with Prior Enlisted Service

N=116

Status	Number	Percent
Prior Enlisted	27	23.3
No Prior Service	89	76.7

Appendix C: Chi-Square Analysis

The chi-square analysis technique is a statistical process that measures goodness of fit for data that falls into categories (5:222). It tests whether significant difference exists between observed cases and the expected value of those cases. It can be employed with nominal or ordinal data.

Chi-square analysis helps to determine whether a systematic relationship exists between two variables (12:223). Observations are tabulated into categories. Expected cell frequencies (values which would be expected if no systematic relationship occurs) are compared to actual cell frequencies from the table according to the formula (12:223):

$$\chi^2 = \sum_i (f_o^i - f_e^i)^2 / f_e^i$$

where: f_o^i = the observed frequency in each cell of the table

f_e^i = the expected frequency calculated as $f_e^i = c_i \cdot r_i / N$

c_i is the frequency of the column marginal

r_i is the frequency of the row marginal

N is the total number of valid cases

As the difference between the observed and expected frequencies increases, χ^2 increases. The significance of the chi-square value also depends on the degrees of freedom of the table. The degrees of freedom (v) are equal to the number of rows and columns in the table. The significance

level may be determined using a chi-square table with for values of (χ^2, ν). For the convenience of the researcher these values are calculated by SPSS, and the associated probability levels are determined.

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This thesis used the Myers-Briggs Type Indicator (MBTI) and a demographic survey to examine the cognitive styles of Air Force civil engineering officers. The survey population was comprised of continuing education students attending the Air Force Institute of Technology, School of Civil Engineering. The MBTI evaluates cognitive preferences using four separate scales to determine an individual's cognitive style. MBTI results were used to obtain a composite profile of cognitive style for Air Force civil engineering officers. The demographic data was used to analyze factors influencing cognitive style among civil engineering officers.

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